subject the results of measurements made by the author during the months March–June, 1918, at the Meteorological Institute in Upsala, Sweden, are presented. The measurements were made with an Ångström pyrgeometer installed on the roof of the instrument house of the institute, and care was taken to keep the metal strips of the instrument oriented parallel to the direction of the wind.

Ångström [2] had already given the following equation for the relation between the cloudiness m and the effective outgoing radiation R_m:

$$R_m = (1 - km)R_0$$

in which R_0 is the actual outward radiation with a cloudless sky. Ångström found from measurements made in California and Algeria that the value of R_0 may be computed from the equation

$$R_0 = \frac{T^4}{293^4}(A + B \cdot 10^{-\gamma p})$$

in which T is the absolute temperature and p is the vapor pressure. He also found the following values for the constants of the equation:
$A = +0.439$; $B = -0.159$; $\gamma = 0.069$; but Asklöf found for A and B the values $+0.126$ and $+0.179$, respectively.

In estimating the cloudiness, m, account must be taken of the thickness of the cloud layer as well as of the kind of clouds. This is done in Sweden and in some other European countries in connection with the regular cloud observations.

For the value of k Ångström gave 0.09, but Asklöf found, for lower clouds only, that 0.083 is a better value. Evidently k must have a different value for different kinds of clouds, as is indicated by the following table, showing the relation between clouds at different levels and the outward radiation:

Clouds.		Number of obser- vations.	Actual outgoing radiation.
Amount.	Kind.		
10	St., Nb., St. Cu.	10	0.023
10	A. St.	2	0.039
10	Ci. St.	5	0.135
0		28	0.149

In a table are given values of R_0 measured on cloudless nights, and of R_m measured on nights when clouds were present. Also, R_0 for both clear and cloudy nights, computed from the equation

$$R_0 = \frac{T^4}{293^4}(0.126 + 0.179 \cdot 10^{-0.069p}) \tag{1}$$

and values of R_m for nights when lower clouds were present obtained by substituting the value of R_0, computed as above for the respective nights, in the equation

$$R_m = (1 - 0.083m) R_0 \tag{2}$$

Not very close agreement can be expected between the observed and computed values of R_m, for the reason that on clear nights the difference between the observed and computed values of R_0 shows a maximum of about ± 15 per cent. Furthermore, at night there is great difficulty in estimating the value of m.

[2] Ångström, A., On the radiation and temperature of snow, and the convection of the air at its surface. Arkiv. för mat., astr. och fys., Bd. 13, No. 21, S. 13–14.

If we substitute in equation (2) the measured value of R_m on a night when lower clouds were observed, and the corresponding computed value of R_0, the equation may be solved for m, and the value obtained will probably be a better measure of the cloud density than the observed m. Such computed values of m are included in the table above referred to. In general, they do not differ from the observed (estimated) value by more than 1 on a scale of 10 for complete cloudiness. It is noticeable that the maximum differences (observed $m=5$, computed $m=8$, and observed $m=4$, computed $m=2$) occur with a partly overcast sky.

It is of interest to compare the above results with measurements made under the direction of the reviewer at Mount Weather, Va., during the months May–September, 1914; in Washington during the months December, 1914–April, 1915; in North Carolina during May, 1915; and published in this REVIEW for February, 1918, **46:** 57–70. The following table summarizes actual radiation measurements with a clear sky, or with lower clouds present.

Clouds.		Number of obser- vation.	Measured outgoing radiation.
Amount.	Kind.		
10	St., St. Cu.	18	0.044
8–9	St. Cu.	10	0.068
5–7	St. Cu.	9	0.078
3–4	St. Cu.	3	0.126
1–2	St., Cu., St. Cu.	5	0.131
0		121	0.160

The above amounts of cloudiness do not take into account the density of the cloud layer, and probably give too much weight to clouds near the horizon.

In measurements of outgoing radiation with the sky completely overcast it must be recognized that the cloud layer may have a higher temperature than the surface air temperature. Such a case is noted in the REVIEW above quoted, page 65. However, in general, it seems evident that nocturnal radiation measurements may be useful in indicating the thickness of the overlying cloud layer, as well as in furnishing data relative to the heat balance between incoming and outgoing radiation.—*H. H. Kimball.*

551.5 : 634

FACTORS CONTROLLING DISTRIBUTION OF FOREST TYPES.

By G. A. PEARSON, Forest Examiner.

Mr. G. A. Pearson, forest examiner of the Fort Valley Forest Experiment Station, presents in two extensive papers published in Ecology for July and October, 1920, an account of his investigations on Factors Controlling Distribution of Forest Types. The following is a summary of Mr. Pearson's results and conclusions:

· 1. Air temperature in the San Francisco mountain region decreases rather uniformly with a rise in altitude, excepting for local inversions in the minimum, which occur between the yellow pine and the Douglas fir types, due to air drainage. The lowest absolute minima and the shortest frostless season occur in the yellow pine type, following closely by the alpine type. The highest temperatures and greatest duration of high temperatures are found in the lowest altitudes. Maximum temperatures decrease uniformly from the lowest to the highest stations. The daily range is greatest in the lower altitudes, decreasing from about 50° F. in the piñon-juniper to about 20° F. in the Engelmann spruce. From the

Engelmann spruce type to timber line there is a noticeable increase in range, due to the exposed situation of the timber line station.

2. Precipitation increases rapidly with altitude up to the Douglas fir type. From the Douglas fir to the Engelmann spruce type it remains almost stationary, but at timber line there appears to be a substantial increase.

3. Wind movement is normally greatest in the higher altitudes, but this relation is not always indicated for the reason that some of the stations are located in the forest while others are in the open. The highest records are obtained at timber line, and the lowest in the spruce forest.

4. Evaporation records show no constant relation to altitude, because wind movement and exposure to sunshine, two of the strongest factors influencing evaporation, vary at the different stations according to density of cover. The highest records obtained are in the pinon-juniper type and the lowest in the Engelmann spruce type.

5. On the basis of origin there are several general soil types in this region. Those in the pinon-juniper type are derived from sandstone, limestone, and basalt. In the yellow pine type local areas of limestone and sandstone occur near the lower limits, but basaltic soils predominate over the type as a whole. Above the yellow pine type all the soils are derived from volcanic rocks.

Probably the most important soil character to be dealt with in this region is the capacity for absorbing and delivering moisture as determined by permeability, water-holding capacity, and wilting coefficient. From this standpoint the heavy clay soils common through the yellow pine type present the least favorable conditions for growth, particularly with respect to natural reproduction. Although these soils have a high water-holding capacity, they also have a high wilting coefficient, and unless mixed with a large proportion of stone and gravel they are exceedingly impervious. High precipitating, low evaporation, and a high degree of permeability tend to create a large moisture supply in the Douglas fir and Engelmann spruce and alpine types.

Soil temperature is of importance mainly through its indirect effects. When the soil temperature falls to 32° F. or even a few degrees above 32°, the soil moisture ceases to be available to plant roots. If this condition persists continuously over long periods during which transpiration is favored by sunshine and wind the result may be fatal to a tree which is unable to endure extreme desiccation.

6. The data obtained indicate that the upper limits of all the forest types are determined primarily by low temperature as related to photosynthesis, and that the lower limits are determined primarily by deficient moisture supply. Low soil temperature, by rendering the soil moisture unavailable to the roots, may under certain conditions, as at timber line, become the upper control; but, at least as far as reproduction is concerned, this is not believed to be a prevalent factor in this region, for the reason that in the high altitudes, the only places where long periods of continuously low soil temperature occur, transpiration in seedlings is reduced to a negligible quantity by a deep snow cover. Deficient moisture rather than high temperature is regarded as the lower control because observations supported by experimental data on nearly all of the species in this region indicate that when adequately supplied with moisture they are capable of enduring high temperature far in excess of those which occur at the lower limits of their natural range.

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RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

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Results of pilot balloon observations at and near Batavia in the years 1911–1918. Batavia. 1920. 104 p. 28 cm. (Verhandelingen no. 6.)

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